PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 February 2001 (20.02.01)	
International application No. PCT/GB99/03556	**Applicant's or agent's file reference** W32333WO
International filing date (day/month/year) 28 October 1999 (28.10.99)	**Priority date** (day/month/year) 16 June 1999 (16.06.99)
Applicant READ, Frank, Henry	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

12 January 2001 (12.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Zakaria EL KHODARY
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Examiner: 01633 813590
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Your Reference: 4/P32317GB
Application No: GB 9914082.4

26 August 1999

Dear Sirs

Patents Act 1977: Search Report under Section 17(5)

I enclose two copies of my search report and two copies of the citations.

Plurality of invention

I consider that your application relates to more than one invention as follows:

(i) The analyser of claim 1 and appendant claims characterised by bringing particles of different energies to longitudinally spaced focus points, and
(ii) The analyser of claim 2 and appendant claims characterised by the selection of a range of elevation entry angles to provide second-order focusing.

My search report relates to the first invention only. If you want the other invention searched, you should file a further Patents Form 9/77.

Publication

I estimate that, provided you have met all formal requirements, preparations for publication of your application will be completed soon after **7 November 2000**. You will then receive a letter informing you of completion and telling you the publication number and date of publication.

Amendment/withdrawal

If you wish to file amended claims for inclusion with the published application, or to withdraw the application to prevent publication, you must do so before the preparations for publication are completed. **No reminder will be issued.** If you write to the Office less

than 3 weeks before the above completion date, please mark your letter prominently: **"URGENT - PUBLICATION IMMINENT".**

Yours faithfully

Martyn Dixon
Examiner

The Patent Office

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Application No: GB 9914082.4 **Examiner:** Martyn Dixon
Claims searched: 1 and appendant claims **Date of search:** 24 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1D (DMB)

Int Cl (Ed.6): H01J (49/44,49/46,49/48)

Other: Online: EPODOC,WPI,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 1387173 A	(Hitachi) see e.g. figs 1 and 2	
A	EP 0255981 A	(Kratos) see fig 20	
A	US 5032724 A	(Perkin-Elmer) see e.g. fig 6	
A	US 4367406 A	(Boston University)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

PATENT COOPERATION TREATY

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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
4/W32333WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/03556	28/10/1999	16/06/1999
International Patent Classification (IPC) or national classification and IPC G01N23/225		
Applicant SHIMADZU RESEARCH LABORATORY (EUROPE) LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 9 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☒ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☒ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	08.10.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Feldhoff, R Telephone No. +49 89 2399 2186

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03556

I. Basis f th report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-33	as originally filed				

Claims, No.:

1-61	as received on	07/09/2001	with letter of	04/09/2001	

Drawings, sheets:

1/9-9/9	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   ☐ the language of publication of the international application (under Rule 48.3(b)).
   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
see separate sheet

6. Additional observations, if necessary:

II. Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:

☐ copy of the earlier application whose priority has been claimed.

☐ translation of the earlier application whose priority has been claimed.

2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid.

Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.

3. Additional observations, if necessary:
see separate sheet

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 61.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 61 are so unclear that no meaningful opinion could be formed (*specify*):
see separat she t

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion

could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-60
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-60
Industrial applicability (IA)	Yes:	Claims	1-60
	No:	Claims	

2. Citations and explanations
see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
se separate sheet

R It m I

Basis of the report

Added Subject-Matter; Article 34(2)(b) PCT

The amendments filed with the letter dated 04.09.2001 introduce subject-matter which extends beyond the content of the application as filed, contrary to Article 34(2)(b) PCT:

Claim 1 (lines 4 and 12) and claims 2, 3, 9, 25-28, 31(2x), 32-34, 36, 38, 39, 41, 46, 48, 49, 53: "axis" should preferably have read "longitudinal axis", which corresponds to the original wording of these claims.

Claim 1, lines 12 and 13: "substantially linearly" and "substantially logarithmically" does not seem to be originally disclosed.

Claim 1: "on a surface of the detection means" does not seem to be originally disclosed in this general form; compare e. g. to original claim 2 (while amending the claims during a possible regional/national phase it should be kept in mind that present claims 29-31 and 51 refer to the feature concerned; "said surface of said detection means").

Claim 2: "detection means ... transverse to said axis" does not seem to be originally disclosed in this general form (compare e. g. to original claim 2).

Claims 8, 12, 13, 18 and 58: "axial direction" should preferably have read "in the direction of said longitudinal axis"

Claim 9: no basis could be found in the original application for the combination of the features of claim 9, now dependent on claim 1, with the features of present claim 1 in this general form (original claims 50 and 51 disclose a similar subject-matter but also include the feature "aperure means", which is not included in present claim 9).

Claim 52: no basis could be found in the original claims and description for the amendments made to this claim.

Basis for amendments being in concordance with Article 34(2)b) PCT

Claim 1: original claims 1, 13 and 14.

Claims 10, 11-21, 22-51, 53-57 and 59-61: renumbered original claims 12, 14-24, 26-55, 58-62 and 64-66.

Claim 58: original claims 63 and 13.

R Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Severe Lack of Clarity of claim 61; Article 6 PCT

The application does not meet the requirements of Article 6 PCT, because claim 61 does not contain any technical features and is thus unclear.

No opinion is therefore given on this claim.

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Prior Art Documents

The following documents (D) cited in the search report is referred to in this communication:

D1: US-A-5 594 244
D2: J. Phys. E: Sci. Instrum. **17**, 1187-1192 (1984)

Lack of Inventive Step of independent claim 1; Article 33(3) PCT

The present application does not meet the requirements of Article 33(3) PCT because the subject-matter of independent claim 1 does not involve an inventive step in the sense of Rule 65 PCT:

Independent claim 1 differs from the disclosure of **D1** (see e. g. abstract, figures 1-3, col. 4, l. 41 - col. 5, l. 59), which is regarded as being the closest state of the art by the feature "equipotentials which ... vary ... linearly in the direction of said axis".

Document **D1** (fig. 1 and col. 2, l. 63) provides, due to the diverging form of the field defining means, an electric field on the surface of the inner field defining means (5) which varies in the direction of the longitudinal axis (with $1/Z_1$). Claim 1 of the present application claims "equipotentials which ... vary ... linearly in the direction of said axis". As can be understood from the description this potential creates an electric field which varies linearly in the direction of said longitudinal axis. It remains unclear which technical effect shall be provided by the difference of a linearly varying potential in the direction of the longitudinal axis over a varying field in this same direction. This feature

can thus only be regarded as a design feature.

Claim 1 thus does not involve an inventive step as required by Art. 33(3) and Rule 65 PCT.

Lack of Inventive Step of independent claim 56; Article 33(3) PCT

The present application does not meet the requirements of Article 33(3) PCT because the subject-matter of independent claim 56 does not involve an inventive step in the sense of Rule 65 PCT:

The subject-matter of independent claim 56, refering to claim 1, differs from the disclosure of **D1** (see e. g. abstract, figures 1-3, col. 4, l. 41 - col. 5, l. 59), which is regarded as being the closest state of the art, by the features

(i) "equipotentials which ... vary ... linearly in the direction of said axis" (claim 1),

(ii) "scaling the applied voltage for operation in the second-order focusing mode at a selected narrower energy range within the first-order operating range".

As discussed with respect to claim 1 feature (i) is only regarded as a design feature. The problem to be solved by feature (ii) may be regarded as how to improve the accuracy of particle energy measurements?".

A similar solution as that suggested in independent claim 56 has been disclosed in document **D2** (see paragraph 2.). The use of an additional narrower adjustment range in order to obtain a fine tuning of the device is regarded as a simple design feature.

The skilled person would, therefore, regard it as a normal procedure to modify the features of **D2** and to combine them with the features of **D1** to arrive at the method as set out in claim 56.

Claim 56 thus does not involve an inventive step as required by Art. 33(3) and Rule 65 PCT.

Dependent claims 2-55 and 57-60 lack an inventive step; Article 33(2, 3) PCT

These dependent claims do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of inventive step in the sense of Article 33(3) and Rule 65 PCT:

Claims 2, 5 and 6: see e. g. **D1**, fig. 2 (11) and col. 5, l. 34-44.

Claims 3 and 4: see e. g. **D1**, col. 11, l. 10-15.

Claim 7: see e. g. **D1**, fig. 2 (11) and col. 5, l. 17-22.

Claim 8: see e. g. **D1**, fig. 2, 3.

Claim 9: a "predetermined angular range in elevation" is provided by the annulus (see e. g. **D1**, fig. 4 (8) and col. 2, l. 61-67). The feature "adjustable for second-order focusing" seems to be a usual feature (see e. g. **D2**).
Claims 10, 25 and 57: see e. g. **D1**, fig. 1, col. 4, l. 36-37 and col. 5, l. 7-9.
Claim 11: see e. g. **D1**, col. 4, l. 52-55.
Claims 12, 13 and 58: "equipotentials which ... vary ... linearly in the direction of said axis"; see the discussion of claim 1. The cylindrical form of the field defining means of claim 12 is regarded as a design feature.
Claim 14: it is assumed that the conductive cones (5, 6) of **D1** are made of an (at least weakly) electrically resistive material.
Claims 32 and 33: see e. g. **D1**, fig. 1.
Claim 35: see e. g. **D1**, col. 4, l. 50.
Claim 36 and 37: see e. g. **D1**, col. 4, l. 61-67.
Claim 42: see e. g. **D1**, col. 6, l. 20-41.
Claim 43: see e. g. **D1**, col. 5, l. 3-16.

Claims 15-24, 26-31, 34, 38-41, 44-51, 52 (orig. claim 56), 53-55, 59 and 60 seem to contain merely usual technical measures which a technical expert would apply without using inventive ability.

Re Item VI
Certain documents cited

Certain published documents (Rule 70.10)
The following intermediate document has been discovered during the search:

Application No Patent No	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date *(valid claim)* *(day/month/year)*
WO-A-99/35668	15-07-1999	12-01-1999	12-01-1998

Although it is not being considered as being state of the art in the sense of Article 33(2,3) PCT because the priority of the application with respect to the priority document GB-A-99 166 54.8 of 15 July 1999 is valid, it might become relevant during the national phase in certain contracting states for assessing novelty.

R Item VII

Certain defects in the international application

Independent claims 1, 9 and 61 are not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble and with the remaining features being included in the characterising part; Rule 6.3 b) PCT and PCT Guidelines III-2.2 and 2.3.

The above-mentioned prior art documents (D1, D2) are not cited and discussed in the description as required by Rule 5.1 a) ii) PCT.

The claims do not contain reference signs in parentheses; Rule 6.2 b) PCT.

Re Item VIII

Certain observations on the international application

Lack of Clarity; Article 6 PCT

Claim 1: "for analysing" should probably not have been replaced by "arranged to analyse".

Claim 1: the expressions "equipotentials ... which vary ... linearly / logarithmically ..." seem to be incorrect that equipotentials vary in a direction. The form of the electric potential could e. g. have been defined by using equation (1) of page 9 (however, this definition would limit the field defining means to a cylindrical form). The logarithmical dependance on the radius (r) of the potential is a consequence of the form of the focusing means. An alternative to the definition of the form of the potential would thus have been the definition of the geometrical configuration of the focusing means.

Claim 1: it remains unclear where the detection means are installed and which form they have. This feature seems, however, to be essential to the performance of the invention. Two different types of detection means are used: see page 9, lines 12-13 and page 15, lines 6-12 AND page 18, line 6-11.

Claim 50: obscure.

Claim 51: "relatively narrow range"; vague.

Claim 56: "virtual source"; unclear.

It seems that the form of the potential as defined in claim 1 is not consistent with the embodiment described on page 13, lines 10-15 and claim 53.

CLAIMS

1. A charged particle energy analyser for analysing charged particles having a range of energies comprising,

electrostatic focusing means having a longitudinal axis,

a charged particle source for directing charged particles into an electrostatic focusing field generated, in use, by said electrostatic focusing means, and

detection means for detecting charged particles focused by said electrostatic focusing means,

wherein said electrostatic focusing field is defined by equipotentials which extend about said longitudinal axis over a predetermined range in azimuth and charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions.

2. An analyser as claimed in claim 1 wherein said charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions that are spaced apart from each other at a surface transverse to said longitudinal axis.

3. An analyser as claimed in claim 2 wherein said surface is orthogonal to said longitudinal axis.

4. An analyser as claimed in claim 2 wherein said surface is planar.

5. An analyser as claimed in claim 2 wherein said surface is curved.

6. An analyser as claimed in claim 5 wherein said surface is conical.

7. An analyer as claimed in any one of claims 2 to 6 wherein said surface is in a field-free region beyond the electrostatic focusing field.

8. An analyser as claimed in claim 1 wherein said charged particles having different energies are brought to a focus by the electrostatic focusing field at discrete positions spaced apart from each other in the longitudinal direction.

9. A charged particle energy analyser for analysing charged particles comprising,

electrostatic focusing means having a longitudinal axis,

a charged particle source for directing charged particles into an electrostatic focusing field generated, in use, by said electrostatic focusing means, and

detection means for detecting charged particles focused by said electrostatic focusing means,

wherein said electrostatic focusing means is defined by equipotentials which extend about said longitudinal axis over a predetermined range in azimuth and said charged particle source directs said charged particles into said electrostatic focusing

field over a predetermined angular range in elevation relative to said longitudinal axis, said predetermined angular range in elevation and/or the axial position of the charged particle source and/or the axial position of the electrostatic focusing field being set or adjustable for second-order focusing of charged particles.

10. An analyser as claimed in any one of claims 1 to 9 wherein said charged particles pass through a region of said electrostatic focusing field defined by equipotentials which vary monotonically in the longitudinal direction.

11. An analyser as claimed in any one of claims 1 to 9 wherein said equipotentials vary monotonically in the longitudinal direction.

12. An analyser as claimed in any one of claims 1 to 11 wherein said equipotentials are symmetrical about said longitudinal axis.

13. An analyser as claimed in any one of claims 1 to 12 wherein said equipotentials vary linearly in said longitudinal direction and vary logarithmically in the radial direction orthogonal to said longitudinal direction.

14. An analyser as claimed in any one of claims 1 to 13 wherein said electrostatic focusing means comprises inner and outer field defining means spanning a predetermined angular range in azimuth about said longitudinal axis, said outer field

defining means being maintained, in use, at a potential relative to said inner field defining means.

15. An analyser as claimed in claim 14 wherein said inner field defining means and said outer field defining means comprise an inner cylinder and an outer cylinder respectively, wherein said inner cylinder is maintained, in use, at a uniform potential and said outer cylinder is maintained, in use, at potential varying monotonically in the longitudinal direction.

16. An analyser as claimed in claim 15 wherein said potential varies linearly in the longitudinal direction.

17. An analyser as claimed in claim 16 wherein said outer cylinder is made from electrically resistive material.

18. An analyser as claimed in claim 14 or claim 15 wherein said outer field defining means comprises a plurality of discrete field defining elements, each said element being maintained, in use, at a different respective potential with respect to said inner field defining means.

19. An analyser as claimed in claim 18 wherein each said field defining element has the form of a ring or hoop.

20. An analyser as claimed in claim 18 wherein each said field defining element has the form of a hollow, truncated cone.

21. An analyser as claimed in claim 14 or claim 15 wherein said outer field defining means comprises a plurality of discrete field defining elements each being made from electrically resistive material and being maintained, in use, at a respective potential which increases monotonically in the longitudinal direction.

22. An analyser as claimed in claim 21 wherein each said element has the form of a cylinder.

23. An analyser as claimed in claim 21 wherein each said element has the form of a hollow, truncated cone.

24. An analyser as claimed in any one of claims 14 to 23 including first and second end elements located at opposite ends of said inner and outer field defining means in respective planes orthogonal to said longitudinal axis, each of said first and second end elements being maintained in use at a potential relative to said inner field defining means which varies non linearly in the radial direction.

25. An analyser as claimed in claim 24 wherein each said end element is maintained in use at a potential relative to said inner field defining means which varies

logarithmically in the radial direction.

26. An analyser as claimed in claim 25 wherein each said element is made from electrically resistive material.

27. An analyser as claimed in claim 24 or claim 25 wherein each said element comprises a plurality of concentric electrically conductive rings each being maintained, in use, at a different respective potential.

28. An analyser as claimed in any one of claims 24 to 27 wherein charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions in the plane of one of said first and second end elements.

29. An analyser as claimed in any one of claims 1 to 11 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field is uniform as a function of azimuthal angle about said longitudinal axis.

30. An analyser as claimed in any one of claims 1 to 11 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field has n-fold rotational symmetry about said longitudinal axis, where n is an integer.

31. An analyser as claimed in claim 14 or claim 15 wherein said inner field defining means and/or said outer field defining means has n-fold rotational symmetry about said longitudinal axis, where n is an integer.

32. An analyser as claimed in claim 31 wherein said inner field defining means comprises a plurality of flat side surfaces having n-fold rotational symmetry about said longitudinal axis, where n is the number of said surfaces.

33. An analyser as claimed in claim 32 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along one or more of said side surfaces and said detection means is located at said one or more side surfaces to detect the focused charged particles.

34. An analyser as claimed in any one of claims 14 to 31 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said detection means is located at and conforms to said inner field defining means to detect the focused charged particles.

35. An analyser as claimed in any one of claims 14 to 17 wherein said charged particles are brought to a focus at said longitudinal axis and said detection means is located on said longitudinal axis to detect the focused charged particles.

36. An analyser as claimed in any one of claims 1 to 35 wherein said charged particle source is located on said longitudinal axis.

37. An analyser as claimed in claim 36 wherein said charged particle source comprises a target located on said longitudinal axis and means for directing radiation onto said target whereby to generate said charged particles.

38. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source comprises a target located on said longitudinal axis and means for directing radiation onto said target whereby to generate said charged particles, said target and said means for directing radiation being located within said inner field defining means.

39. An analyser as claimed in claim 37 or claim 38 wherein said means for directing radiation is an electron gun.

40. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over a predetermined angular range in azimuth about said longitudinal axis.

41. An analyser as claimed in claim 40 wherein said charged particle source directs said charged particles into said electrostatic focusing field over the entire (360°)

angular range in azimuth.

42. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more discrete angular ranges in azimuth about said longitudinal axis.

43. An analyser as claimed in claim 14 wherein said charged particle source directs charged particles into said electrostatic focusing field over one or more predetermined angular range in azimuth about said longitudinal axis, said charged particles being admitted to the electrostatic focusing field by one or more windows in the inner field defining means.

44. An analyser as claimed in claim 43 wherein the or each said window has the form of an electrically conductive grid or mesh.

45. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more predetermined angular range in azimuth about said longitudinal axis, and said detection means is so configured and arranged as to detect charged particles derived from each said angular range.

46. An analyser as claimed in any one of claims 1 to 45 wherein said detection

means comprises one or more detector selected from a multi channel array detector, a microsphere array detector and a position-sensitive resistive plate detector.

47. An analyser as claimed in claim 46 wherein said one or more detector incorporates a phosphor-coated detection plate.

48. An analyser as claimed in any one of claims 1 to 47 including means for adjusting the axial position of said charged particle source.

49. An analyser as claimed in claim 14 including means for adjusting said potential whereby to vary the axial position of the electrostatic focusing field relative to said charged particle source.

50. An analyser as claimed in any one of claims 1 to 49 wherein said charged particle source includes aperture means for directing charged particles onto said electrostatic focusing field over a predetermined angular range in elevation relative to said longitudinal axis.

51. An analyser as claimed in claim 50 wherein said predetermined angular range in elevation and/or the axial position of said charged particle source and/or the axial position of the electrostatic focusing field are set or adjustable for second-order focusing of charged particles having a relatively narrow range of energies.

52. An analyser as claimed in any one of claims 1 to 51 wherein said charged particle source directs said charged particles from a location or locations offset from said longitudinal axis.

53. An analyser as claimed in claim 52 wherein said charged particle source includes means for focusing charged particles at said location or locations.

54. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source and said detection means are both located between said longitudinal axis and said inner field defining means.

55. An analyser as claimed in any one of claims 14 to 27 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said detection means comprises a detector located radially inwards or radially outwards of the inner field defining means and means for focusing said focused charged particles onto the detector.

56. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source forms a virtual source at said inner field defining means.

57. An analyser as claimed in claim 56 wherein said charged particle source includes means for focusing charged particles at said virtual source.

58. An analyser as claimed in claim 14 wherein said outer field defining means comprises a curved plate having rotational symmetry about said longitudinal axis.

59. An analyser as claimed in claim 58 wherein said curved plate is maintained at a uniform potential.

60. An analyser as claimed in claim 28 wherein said one element is maintained at zero potential.

61. A method for operating a charged particle energy analyser as claimed in any one of claims 1 to 60 comprising the steps of applying voltage to said electrostatic focusing means for operation in the first-order focusing mode within a predetermined energy range and scaling the applied voltage for operation in the second-order focusing mode at a selected narrower energy range within said predetermined energy range.

62. An analyser as claimed in any one of claims 1 to 13 wherein said predetermined range in azimuth is the entire (360°) azimuthal range.

63. An analyser as claimed in claim 14 wherein said inner and outer field defining means comprises an inner cylindrical segment and an outer cylindrical segment respectively, wherein said inner and outer cylindrical segments extend over a

predetermined angular range in azimuth and said outer cylindrical segment is maintained, in use, at a potential varying monotonically in the longitudinal direction.

64. An analyser as claimed in claim 63 wherein the longitudinal side edges of the inner and outer cylindrical segments are joined by side walls.

65. An analyser as claimed in claim 64 wherein said side walls are adapted to define a predetermined potential distribution over their inward facing surfaces.

66. An analyser as hereinbefore defined with reference to the accompanying drawings.

ABSTRACT

CHARGED PARTICLE ENERGY ANALYSERS

A charged particle energy analyser (Figure 1) comprises a source of electrons 1 and inner and outer cylinders (2,3) arranged concentrically about a longitudinal axis (z-z). Electrical potential applied to the outer cylinder (3) creates an electrostatic field between the cylinders (2,3) defined by equipotentials which are symmetrical about the longitudinal axis z-z and increase linearly in the longitudinal direction and logarithmically in the radial direction. Electrons having different energies are focused by the electrostatic field at discrete positions spaced apart from each other in the longitudinal direction. Also described is a charged particle energy analyser (Figure 6) in which electrons having different energies are fcoused by the electrostatic field at discrete positions at a surface transverse to the longitudinal axis. Both analysers may operate in the second-order focusing mode.

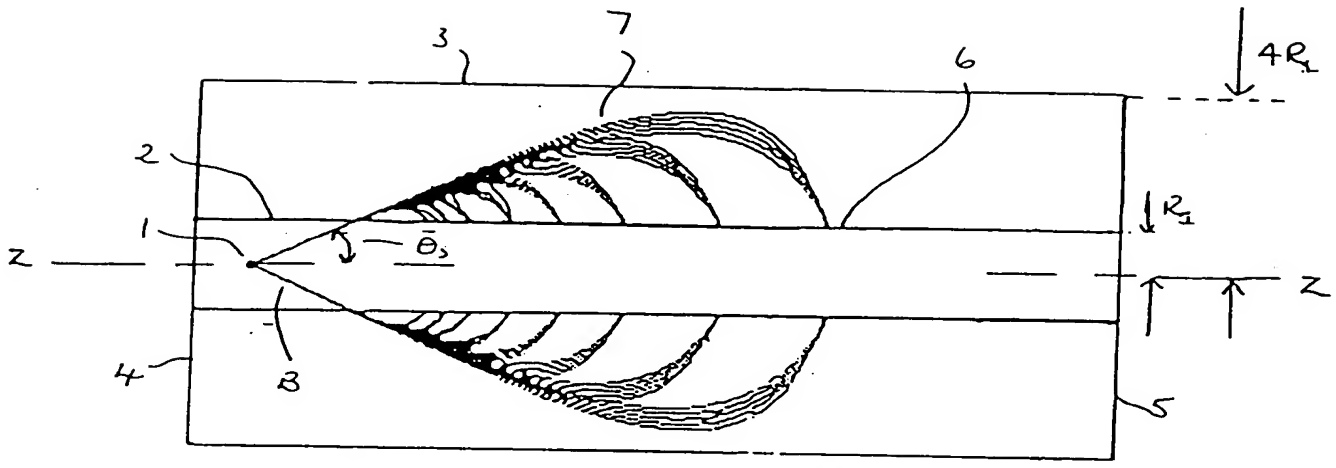


Figure 1

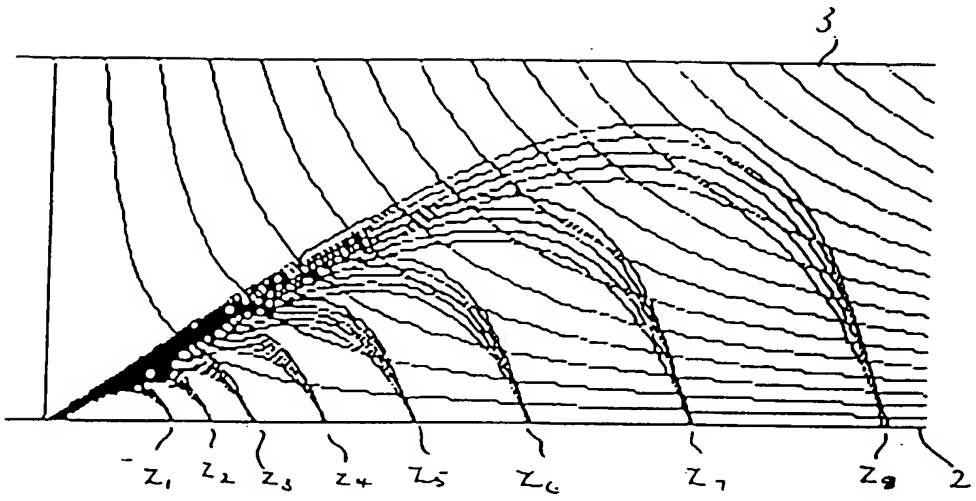


Figure 2

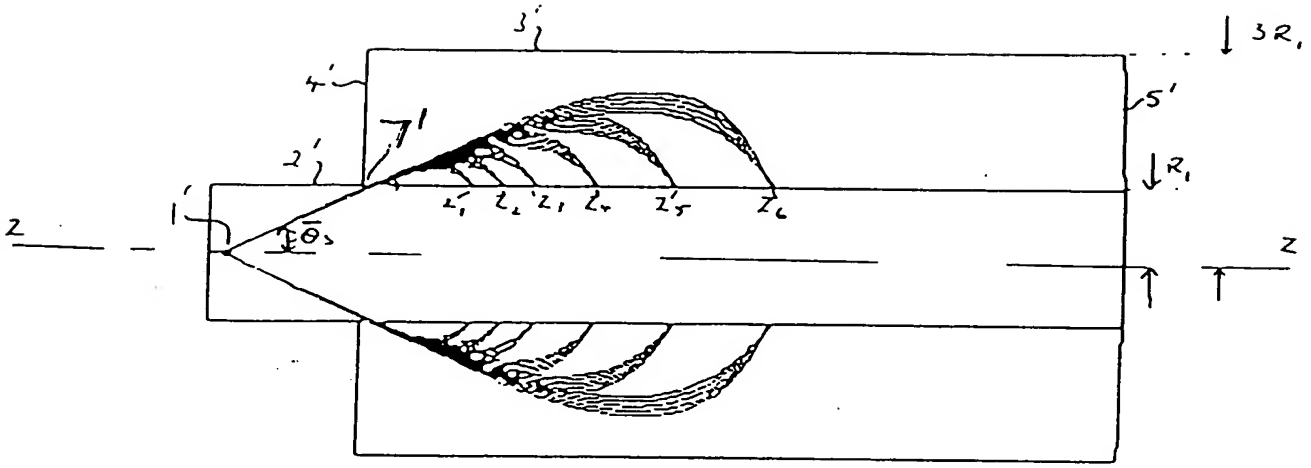


Figure 3

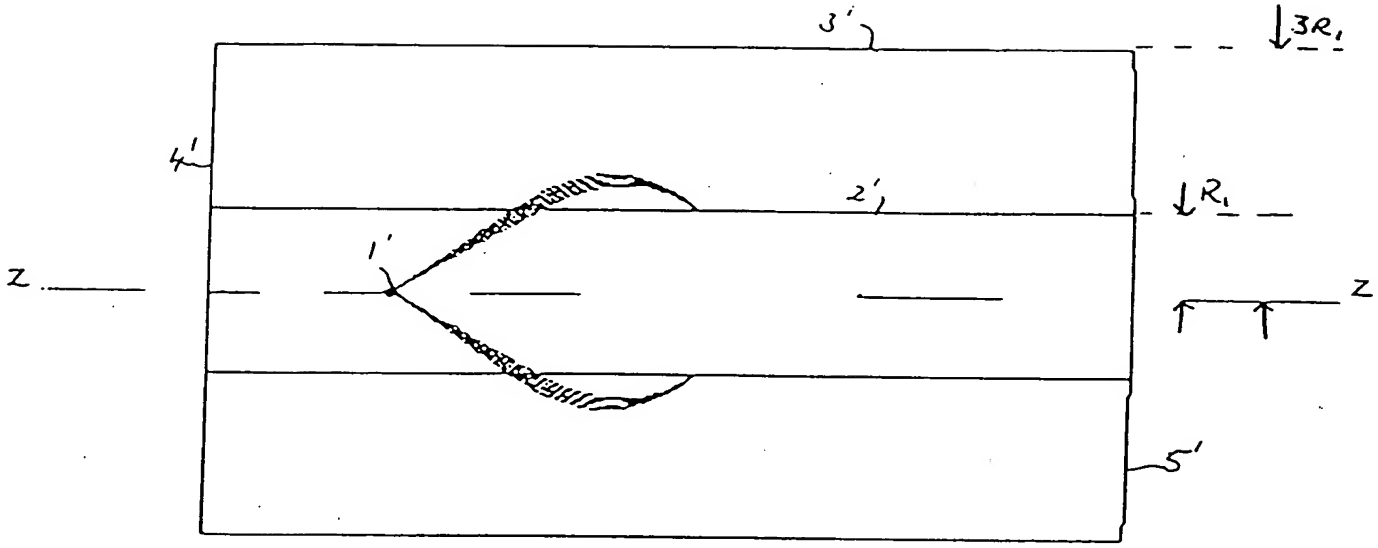


Figure 4

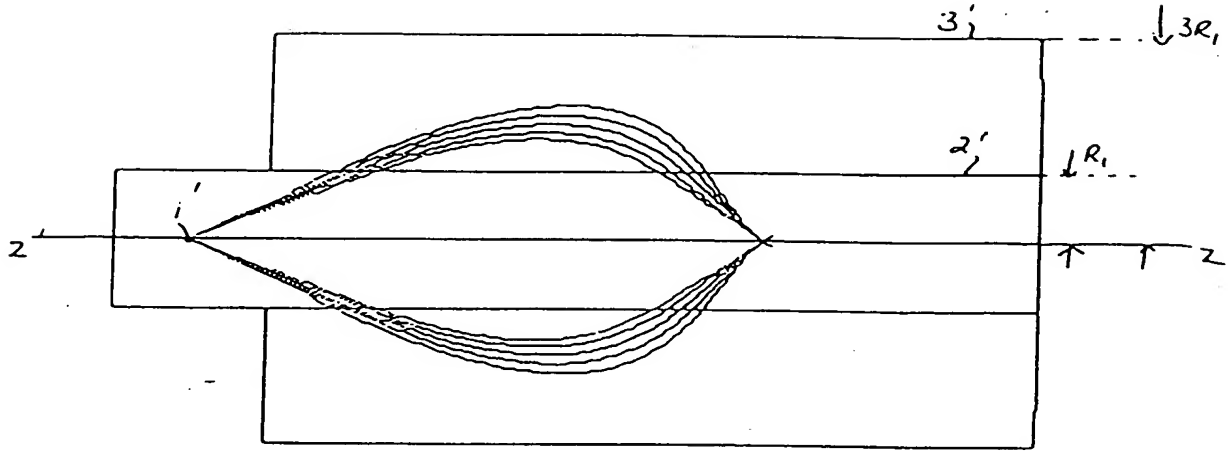


Figure 5

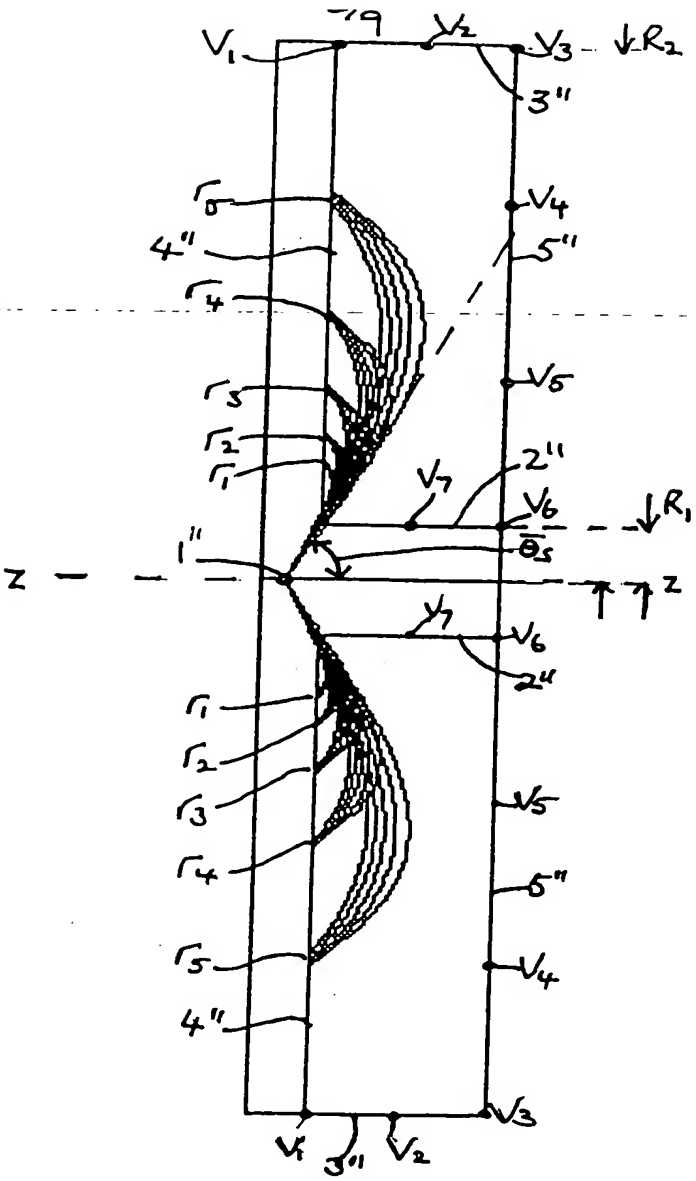

V1
V2
V3
R2
3"
r0
V4
4"
5"
r4
r3
V5
r2
r1
V7
2"
V6
R1
1"
θs
z
z
V7
V6
2"
r1
r2
r3
V5
r4
5"
r5
V4
4"
V3
V1
3"
V2

FIG 6

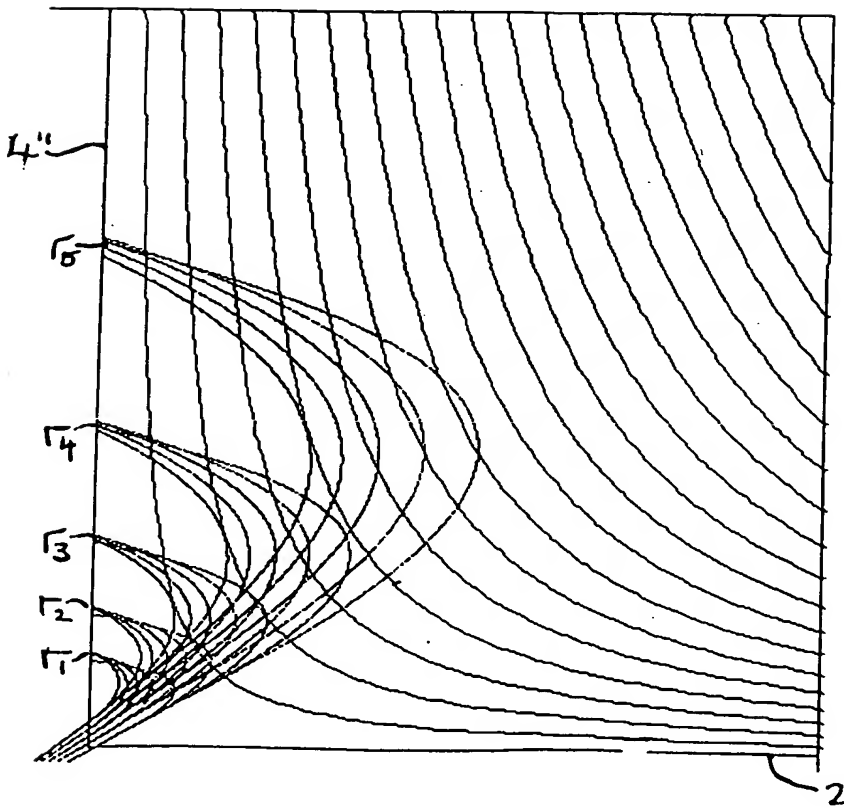

4"
r0
r4
r3
r2
r1
2"

FIG 7

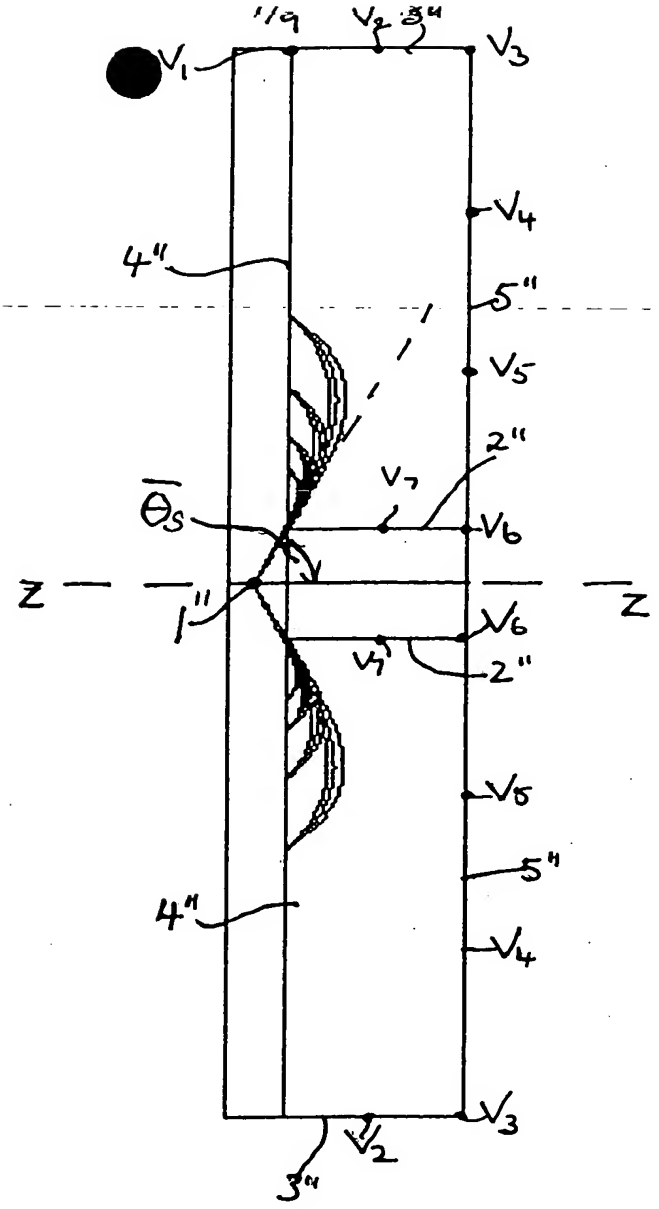


FIG 8

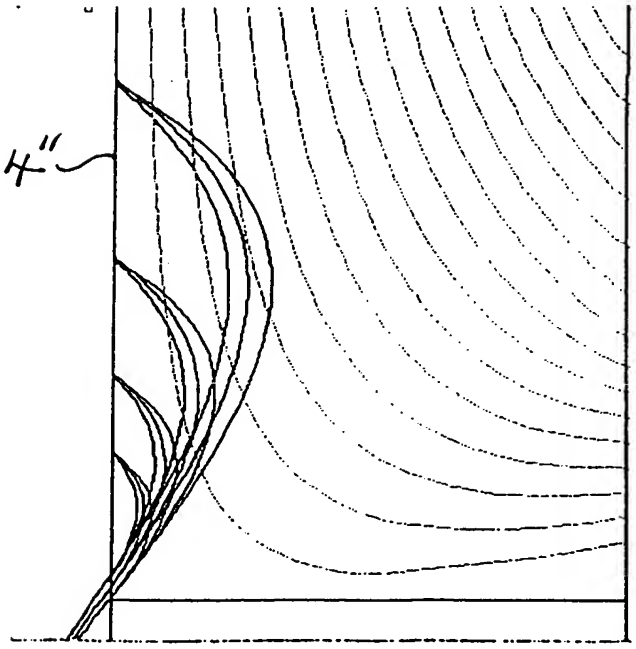


FIG 9

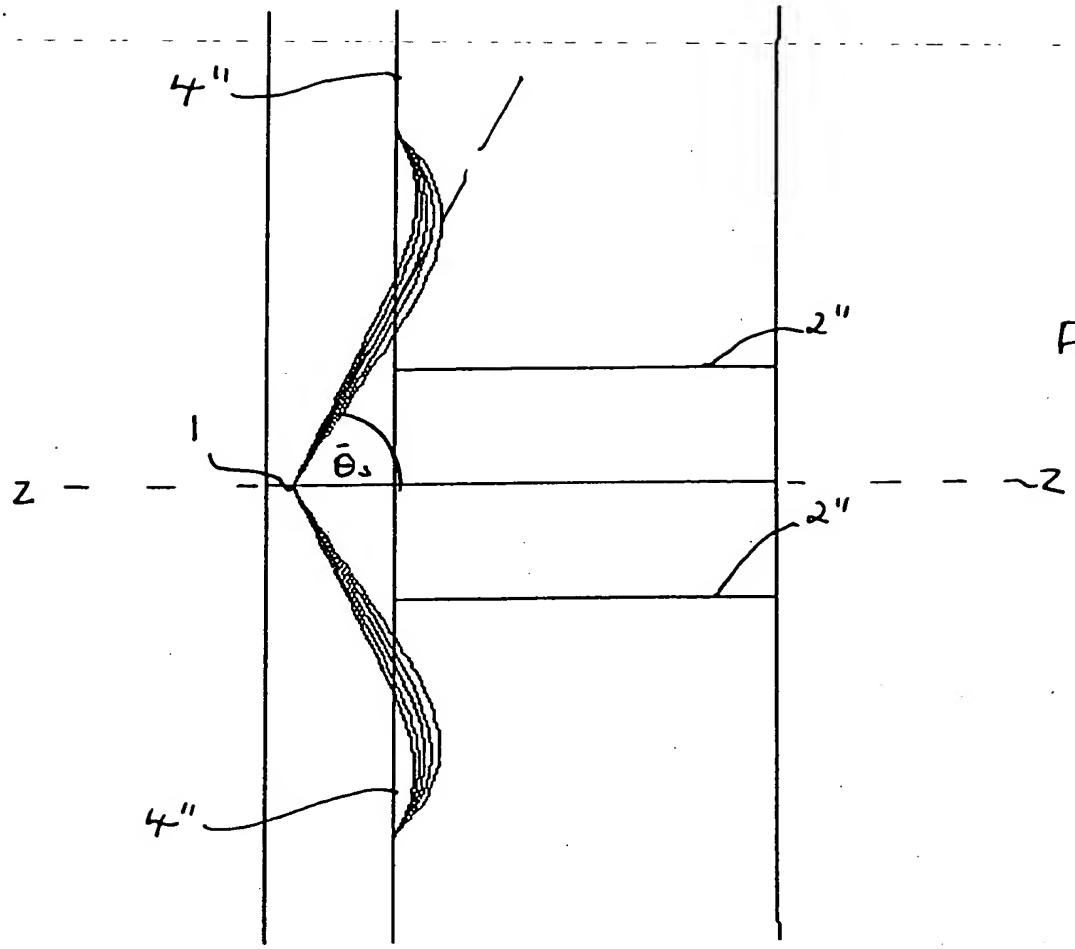


FIG 10

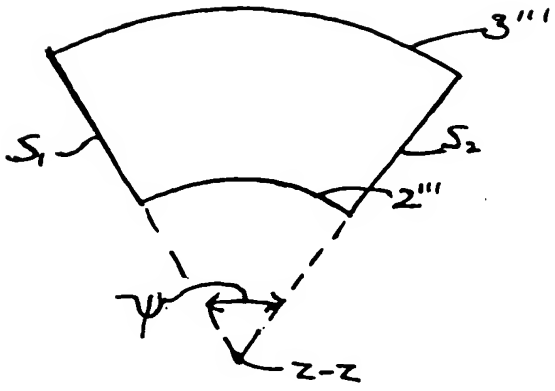
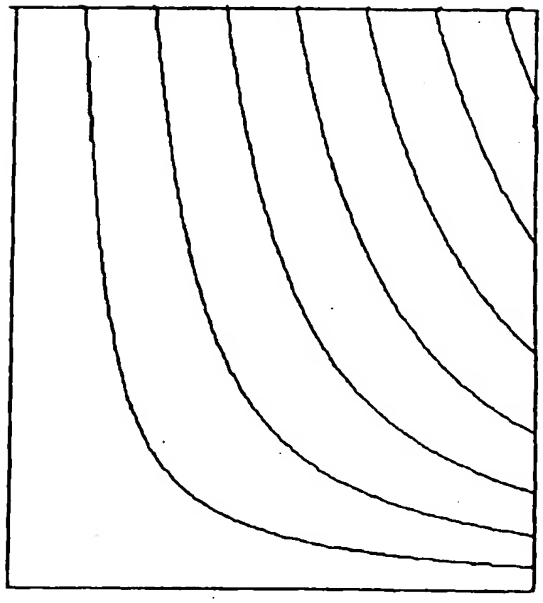


FIG 11a

FIG11b



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 December 2000 (21.12.2000)

PCT

(10) International Publication Number
WO 00/77504 A1

(51) International Patent Classification[7]: G01N 23/225, 23/227, H01J 49/48

(21) International Application Number: PCT/GB99/03556

(22) International Filing Date: 28 October 1999 (28.10.1999)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9914082.4 16 June 1999 (16.06.1999) GB
9916654.8 15 July 1999 (15.07.1999) GB

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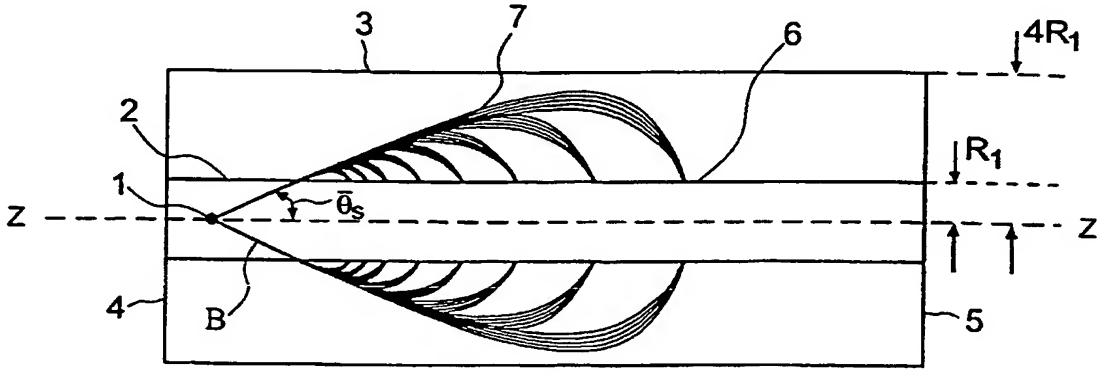
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ELECTRICALLY-CHARGED PARTICLE ENERGY ANALYSERS



(57) Abstract: A charged particle energy analyser (Figure 1) comprises a source of electrons (1) and inner and outer cylinders (2, 3) arranged concentrically about a longitudinal axis (z-z). Electrical potential applied to the outer cylinder (3) creates an electrostatic field between the cylinders (2, 3) defined by equipotentials which are symmetrical about the longitudinal axis z-z and increase linearly in the longitudinal direction and logarithmically in the radial direction. Electrons having different energies are focused by the electrostatic field at discrete positions spaced apart from each other in the longitudinal direction. Also described is a charged particle energy analyser (Figure 6) in which electrons having different energies are focused by the electrostatic field at discrete positions at a surface transverse to the longitudinal axis. Both analysers may operate in the second-order focusing mode.

WO 00/77504 A1

CLAIMS

1. A charged particle energy analyser for analysing charged particles having a range of energies comprising,

electrostatic focusing means having a longitudinal axis,

a charged particle source for directing charged particles into an electrostatic focusing field generated, in use, by said electrostatic focusing means, and

detection means for detecting charged particles focused by said electrostatic focusing means,

wherein said electrostatic focusing field is defined by equipotentials which extend about said longitudinal axis over a predetermined range in azimuth and charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions.

2. An analyser as claimed in claim 1 wherein said charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions that are spaced apart from each other at a surface transverse to said longitudinal axis.

3. An analyser as claimed in claim 2 wherein said surface is orthogonal to said longitudinal axis.

4. An analyser as claimed in claim 2 wherein said surface is planar.

5. An analyser as claimed in claim 2 wherein said surface is curved.

6. An analyser as claimed in claim 5 wherein said surface is conical.

7. An analyer as claimed in any one of claims 2 to 6 wherein said surface is in a field-free region beyond the electrostatic focusing field.

8. An analyser as claimed in claim 1 wherein said charged particles having different energies are brought to a focus by the electrostatic focusing field at discrete positions spaced apart from each other in the longitudinal direction.

9. A charged particle energy analyser for analysing charged particles comprising,

electrostatic focusing means having a longitudinal axis,

a charged particle source for directing charged particles into an electrostatic focusing field generated, in use, by said electrostatic focusing means, and

detection means for detecting charged particles focused by said electrostatic focusing means,

wherein said electrostatic focusing means is defined by equipotentials which extend about said longitudinal axis over a predetermined range in azimuth and said charged particle source directs said charged particles into said electrostatic focusing

field over a predetermined angular range in elevation relative to said longitudinal axis, said predetermined angular range in elevation and/or the axial position of the charged particle source and/or the axial position of the electrostatic focusing field being set or adjustable for second-order focusing of charged particles.

10. An analyser as claimed in any one of claims 1 to 9 wherein said charged particles pass through a region of said electrostatic focusing field defined by equipotentials which vary monotonically in the longitudinal direction.

11. An analyser as claimed in any one of claims 1 to 9 wherein said equipotentials vary monotonically in the longitudinal direction.

12. An analyser as claimed in any one of claims 1 to 11 wherein said equipotentials are symmetrical about said longitudinal axis.

13. An analyser as claimed in any one of claims 1 to 12 wherein said equipotentials vary linearly in said longitudinal direction and vary logarithmically in the radial direction orthogonal to said longitudinal direction.

14. An analyser as claimed in any one of claims 1 to 13 wherein said electrostatic focusing means comprises inner and outer field defining means spanning a predetermined angular range in azimuth about said longitudinal axis, said outer field

defining means being maintained, in use, at a potential relative to said inner field defining means.

15. An analyser as claimed in claim 14 wherein said inner field defining means and said outer field defining means comprise an inner cylinder and an outer cylinder respectively, wherein said inner cylinder is maintained, in use, at a uniform potential and said outer cylinder is maintained, in use, at potential varying monotonically in the longitudinal direction.

16. An analyser as claimed in claim 15 wherein said potential varies linearly in the longitudinal direction.

17. An analyser as claimed in claim 16 wherein said outer cylinder is made from electrically resistive material.

18. An analyser as claimed in claim 14 or claim 15 wherein said outer field defining means comprises a plurality of discrete field defining elements, each said element being maintained, in use, at a different respective potential with respect to said inner field defining means.

19. An analyser as claimed in claim 18 wherein each said field defining element has the form of a ring or hoop.

20. An analyser as claimed in claim 18 wherein each said field defining element has the form of a hollow, truncated cone.

21. An analyser as claimed in claim 14 or claim 15 wherein said outer field defining means comprises a plurality of discrete field defining elements each being made from electrically resistive material and being maintained, in use, at a respective potential which increases monotonically in the longitudinal direction.

22. An analyser as claimed in claim 21 wherein each said element has the form of a cylinder.

23. An analyser as claimed in claim 21 wherein each said element has the form of a hollow, truncated cone.

24. An analyser as claimed in any one of claims 14 to 23 including first and second end elements located at opposite ends of said inner and outer field defining means in respective planes orthogonal to said longitudinal axis, each of said first and second end elements being maintained in use at a potential relative to said inner field defining means which varies non linearly in the radial direction.

25. An analyser as claimed in claim 24 wherein each said end element is maintained in use at a potential relative to said inner field defining means which varies

logarithmically in the radial direction.

26. An analyser as claimed in claim 25 wherein each said element is made from electrically resistive material.

27. An analyser as claimed in claim 24 or claim 25 wherein each said element comprises a plurality of concentric electrically conductive rings each being maintained, in use, at a different respective potential.

28. An analyser as claimed in any one of claims 24 to 27 wherein charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions in the plane of one of said first and second end elements.

29. An analyser as claimed in any one of claims 1 to 11 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field is uniform as a function of azimuthal angle about said longitudinal axis.

30. An analyser as claimed in any one of claims 1 to 11 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field has n-fold rotational symmetry about said longitudinal axis, where n is an integer.

31. An analyser as claimed in claim 14 or claim 15 wherein said inner field defining means and/or said outer field defining means has n-fold rotational symmetry about said longitudinal axis, where n is an integer.

32. An analyser as claimed in claim 31 wherein said inner field defining means comprises a plurality of flat side surfaces having n-fold rotational symmetry about said longitudinal axis, where n is the number of said surfaces.

33. An analyser as claimed in claim 32 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along one or more of said side surfaces and said detection means is located at said one or more side surfaces to detect the focused charged particles.

34. An analyser as claimed in any one of claims 14 to 31 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said detection means is located at and conforms to said inner field defining means to detect the focused charged particles.

35. An analyser as claimed in any one of claims 14 to 17 wherein said charged particles are brought to a focus at said longitudinal axis and said detection means is located on said longitudinal axis to detect the focused charged particles.

36. An analyser as claimed in any one of claims 1 to 35 wherein said charged particle source is located on said longitudinal axis.

37. An analyser as claimed in claim 36 wherein said charged particle source comprises a target located on said longitudinal axis and means for directing radiation onto said target whereby to generate said charged particles.

38. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source comprises a target located on said longitudinal axis and means for directing radiation onto said target whereby to generate said charged particles, said target and said means for directing radiation being located within said inner field defining means.

39. An analyser as claimed in claim 37 or claim 38 wherein said means for directing radiation is an electron gun.

40. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over a predetermined angular range in azimuth about said longitudinal axis.

41. An analyser as claimed in claim 40 wherein said charged particle source directs said charged particles into said electrostatic focusing field over the entire (360°)

angular range in azimuth.

42. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more discrete angular ranges in azimuth about said longitudinal axis.

43. An analyser as claimed in claim 14 wherein said charged particle source directs charged particles into said electrostatic focusing field over one or more predetermined angular range in azimuth about said longitudinal axis, said charged particles being admitted to the electrostatic focusing field by one or more windows in the inner field defining means.

44. An analyser as claimed in claim 43 wherein the or each said window has the form of an electrically conductive grid or mesh.

45. An analyser as claimed in any one of claims 1 to 39 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more predetermined angular range in azimuth about said longitudinal axis, and said detection means is so configured and arranged as to detect charged particles derived from each said angular range.

46. An analyser as claimed in any one of claims 1 to 45 wherein said detection

means comprises one or more detector selected from a multi channel array detector, a microsphere array detector and a position-sensitive resistive plate detector.

47. An analyser as claimed in claim 46 wherein said one or more detector incorporates a phosphor-coated detection plate.

48. An analyser as claimed in any one of claims 1 to 47 including means for adjusting the axial position of said charged particle source.

49. An analyser as claimed in claim 14 including means for adjusting said potential whereby to vary the axial position of the electrostatic focusing field relative to said charged particle source.

50. An analyser as claimed in any one of claims 1 to 49 wherein said charged particle source includes aperture means for directing charged particles onto said electrostatic focusing field over a predetermined angular range in elevation relative to said longitudinal axis.

51. An analyser as claimed in claim 50 wherein said predetermined angular range in elevation and/or the axial position of said charged particle source and/or the axial position of the electrostatic focusing field are set or adjustable for second-order focusing of charged particles having a relatively narrow range of energies.

52. An analyser as claimed in any one of claims 1 to 51 wherein said charged particle source directs said charged particles from a location or locations offset from said longitudinal axis.

53. An analyser as claimed in claim 52 wherein said charged particle source includes means for focusing charged particles at said location or locations.

54. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source and said detection means are both located between said longitudinal axis and said inner field defining means.

55. An analyser as claimed in any one of claims 14 to 27 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said detection means comprises a detector located radially inwards or radially outwards of the inner field defining means and means for focusing said focused charged particles onto the detector.

56. An analyser as claimed in any one of claims 14 to 27 wherein said charged particle source forms a virtual source at said inner field defining means.

57. An analyser as claimed in claim 56 wherein said charged particle source includes means for focusing charged particles at said virtual source.

58. An analyser as claimed in claim 14 wherein said outer field defining means comprises a curved plate having rotational symmetry about said longitudinal axis.

59. An analyser as claimed in claim 58 wherein said curved plate is maintained at a uniform potential.

60. An analyser as claimed in claim 28 wherein said one element is maintained at zero potential.

61. A method for operating a charged particle energy analyser as claimed in any one of claims 1 to 60 comprising the steps of applying voltage to said electrostatic focusing means for operation in the first-order focusing mode within a predetermined energy range and scaling the applied voltage for operation in the second-order focusing mode at a selected narrower energy range within said predetermined energy range.

62. An analyser as claimed in any one of claims 1 to 13 wherein said predetermined range in azimuth is the entire (360°) azimuthal range.

63. An analyser as claimed in claim 14 wherein said inner and outer field defining means comprises an inner cylindrical segment and an outer cylindrical segment respectively, wherein said inner and outer cylindrical segments extend over a

predetermined angular range in azimuth and said outer cylindrical segment is maintained, in use, at a potential varying monotonically in the longitudinal direction.

64. An analyser as claimed in claim 63 wherein the longitudinal side edges of the inner and outer cylindrical segments are joined by side walls.

65. An analyser as claimed in claim 64 wherein said side walls are adapted to define a predetermined potential distribution over their inward facing surfaces.

66. An analyser as hereinbefore defined with reference to the accompanying drawings.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
W32333WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/03556	28/10/1999	16/06/1999
Applicant		
SHIMADZU RESEARCH LABORATORY (EUROPE) LTD. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of Invention is lacking** (see Box II).

4. With regard to the **title,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   ELECTRICALLY-CHARGED PARTICLE ENERGY ANALYSERS

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03556

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N23/225 G01N23/227 H01J49/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 99 35668 A (EL GOMATI MOHAMED MOCHTAR ;UNIV YORK (GB); JACKA MARCUS (GB); PRUT) 15 July 1999 (1999-07-15) page 6, line 11 - line 13 page 9, line 14 - line 18 figures 5-7,10 --- -/--	1,2,4-6, 8-12, 14-16, 18-20, 24,27, 28, 34-41, 43,44, 46-49, 55,56, 58-60, 62,63,66

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2000	23/08/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Navas Montero, E

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 594 244 A (PRUTTON MARTIN) 14 January 1997 (1997-01-14)	1,2,4-9, 12,14, 20,22, 23,29, 34-41, 43,44, 46-49, 58-60, 62,66
Y	column 1, line 66 -column 2, line 9 column 2, line 37 - line 40 column 4, line 49 - line 60 column 5, line 17 - line 59 figures 1-3	17,21, 26,27, 30-33,50
Y	US 3 735 128 A (PALMBERG P) 22 May 1973 (1973-05-22) column 3, line 25 -column 4, line 32; figures 1-4	17,21, 26,27
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